Towards an integrated approach for monitoring the effects of chemical contaminants in the Spanish coastal Mediterranean waters

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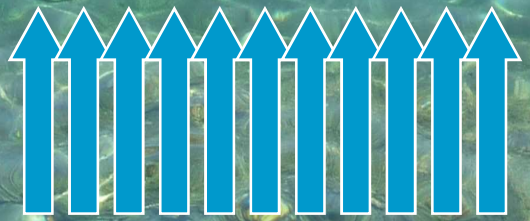
Ecosystem-based approach

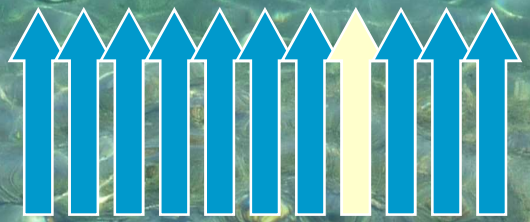
Marine health status



European Union
MSFD (2008/56/EC)

Ecosystem-based approach

Marine health status

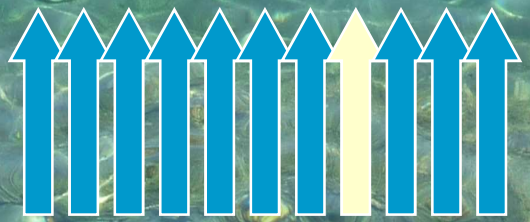


European Union
MSFD (2008/56/EC)

Descriptor 8: Concentration of contaminants are at level not giving rise to pollution effects

Ecosystem-based approach

Marine health status



ICES/OSPAR

MED POL

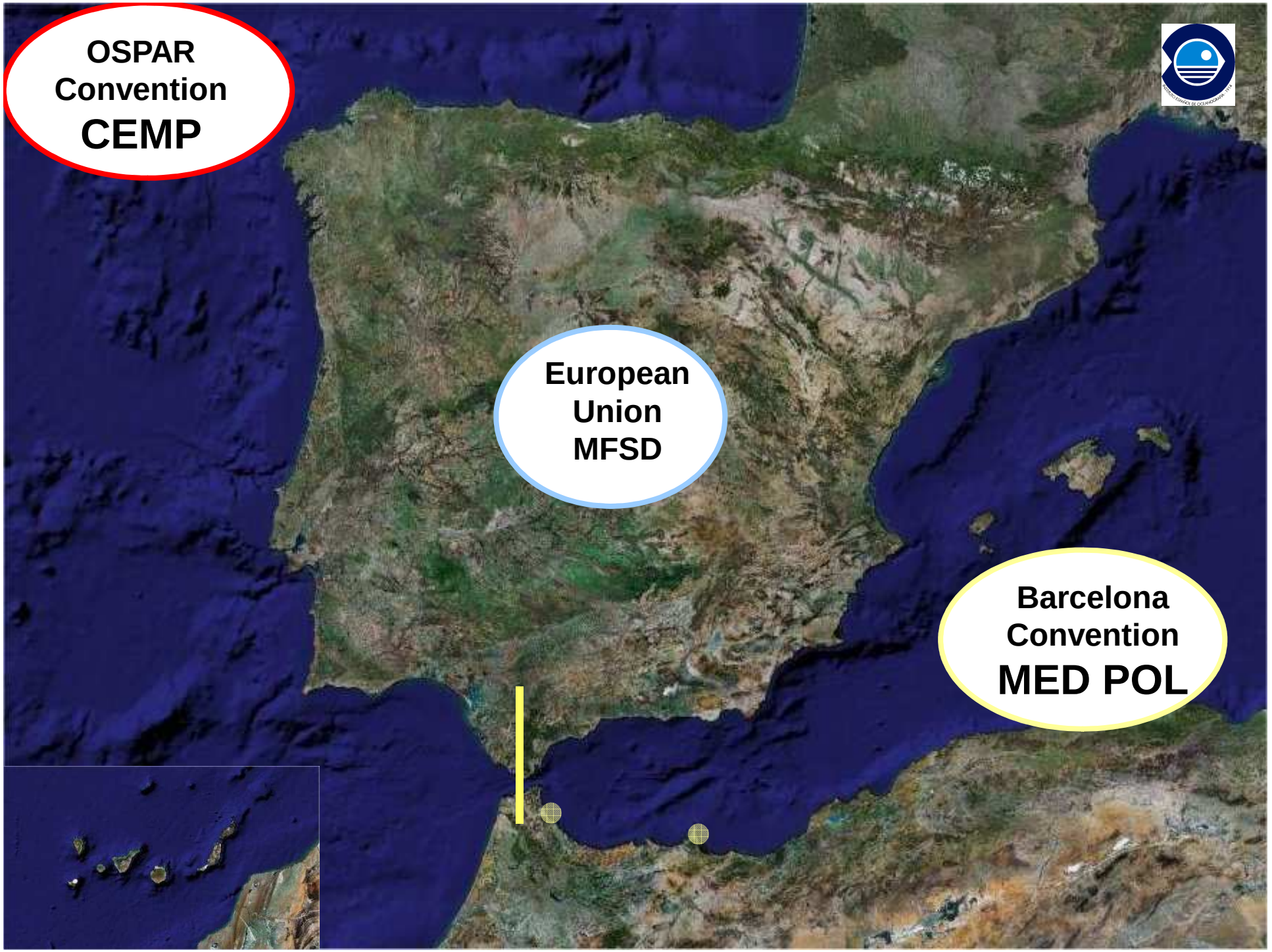
European Union
MSFD (2008/56/EC)

Chemical and biological effect measurements

Water

Sediment

Biota


OSPAR
Convention
CEMP
European
Union
MFSD
Barcelona
Convention
MED POL

BARCELONA CONVENTION

Environmental assessment component

MED POL PROGRAMME

Mediterranean Action Plan

MED POL Phase IV (2006-2013)

Strategy for the development of Mediterranean Marine Pollution Indicators (MPIs)(UNEP, 2003)

MARINE ECOSYSTEM APPROACH: MPIs

BIOLOGICAL INDICATORS

Number of exotic species (all taxa)
Number of zoobenthic species (S)
Presence/abundance of sensitive/opportunixtic zoobenthic especies/taxa
Community diversity (zoobenthos/phytobenthos)
Presence and coverage of benthic macrophytes (sensitive/opportunistic):POMI
Biotic index (EEI, BENTIX)

BIOMARKERS

Stress on stress (survival in air) in molluscs
Lysosomal membrane stabililty in molluscs and fish cells
Lipofucsin lysosomal accumulation in molluscs and fish cells
Neutral lipid lysosomal accumulation in molluscs and fish cells
Frequency of micronuclei in molluscs and fish cells
DNA damge in molluscs and fish cells
Peroxisome proliferation
Methallothionein in molluscs cells
AChE in molluscs
EROD activity

CHEMICAL INDICATORS

Referred to hardazous substances	HMB = heavy metals in Biota
	HME= Heavy metals in Effluent
	HMS = Heavy metals in sediment
	OCB = Organichlorines in Biota
	OCE = Organochlorines in Effluent
	OCS = Organochlorines in Sediment
	PHS = Petroleum Hydrocarbons in Sediment
	PHB = Petroleum hydrocarbons in Biota
	PHE = Petroleum hydrocarbons in Effluent
	BBW = Bacteria in bathing waters
	BSW = Bacteria in shellfish growing waters
Referred to eutrophication	Chl = Chlorophyll a
	NO3, NO2, NH4 = Nitrates, Nitrites and Ammonium
	PO4 = Orthophosphates
	N, P = Total N and Total P
	Tr = Transparency
	BOD = Biological Oxygen Demand
Referred to the marine environment related to Climate Change	T/S = Temperature and Salinity

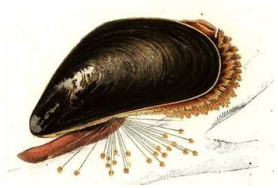
MEDPOL Phase IV (2006-2013):

Strategy for the development of Mediterranean Marine Pollution Indicators **(MPIs),** (UNEP, 2003)

Biomonitoring programs conducted by MCBE (IEO) along the Mediterranean coast: Main goals

BMCW program: Biomonitoring Program of contamination in Spanish Mediterranean coastal waters

- To establish the **spatial distribution** of selected contaminants and biological responses in native mussel populations in a number of coastal stations, hot spots and reference stations;
- To establish the **temporal trends** of selected contaminants and biological responses in native mussel populations in a number of coastal stations, hot spots and reference stations;
- To perform an **integrated assessment** of chemical quality of the coastal waters by using mussels and to monitor it over time.



Contaminant concentrations + **Biomarkers**

Bionmonitoring program conducted by MCBE (IEO) along the Mediterranean coast: Main goals

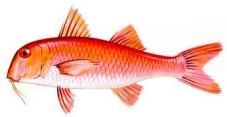
BMIS program: Biomonitoring Program of contamination in Spanish Mediterranean inner shelf ecosystem

1) To establish the **spatial distribution** and **temporal trends** of selected contaminants in superficial sediments in the target MED POL fish species red mullet (*Mullus barbatus*) (UNEP/RAMOGE, 1999) along the Iberian Mediterranean inner shelf;

2) To establish the **spatial variations** and **temporal trends** of biomarker responses in red mullet;

3) To establish the **toxicity associated** to the superficial sediments in areas along the Iberian Mediterranean inner shelf and assess them over time;

4) To perform an **integrated assessment** of chemical quality of the inner shelf bottoms and to monitor it over time.

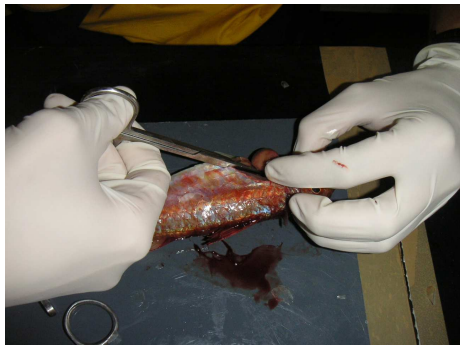


Contaminant concentrations + **Biological effects**

CHEMICAL CONTAMINANTS

Recommendations of MEDPOL Programme and also considering OSPAR.

Use of reference materials, **QUASIMEME** and **IAEA** intercomparison exercises



TRACE METALS	Mercury
	Lead
	Cadmium
	Copper
	Zinc
	Arsenic
	Nickel
	Aluminium
ORGANOCHLORINATED COMPOUNDS	Polychlorinated byphenyls: CB28, CB52, CB101, CB105, CB118, CB138, CB153, CB156, B180.
	pp 'DDE, *pp* 'DDT y *op* 'DDT
	γ -Hexachlorocyclohexane
	α -Hexachlorocyclohexane
	Hexachlorobencene
	Transnonachlor
	Dieldrin
	Aldrin
POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)	Phenanthrene
	Anthracene
	Fluoranthene
	Pyrene
	Benzo[a]anthracene
	Chrysene
	Benzo[e]pyrene
	Benzo[b]fluoranthene
	Benzo[k]fluoranthene
	Benzo[a]pyrene
	Benzo[g,h,i]perylene
	Dibenzo[a,h]anthracene
	Indeno[1,2,3-c,d]pyrene

AAS: Graphite furnace, flameless atomic.

Cold vapour technique

GC: ECD detector, helium carrier gas

HPLC: UV detector, water-metanol gradient phase

BIOMARKERS and BIOASSAYS

BEQUALM and **MEDPOL** (Prof. A. Viarengo)

Mussel

- Stress on Stress
- Stability lysosomal
- Micronuclei
- AChE
- Metallothioneins

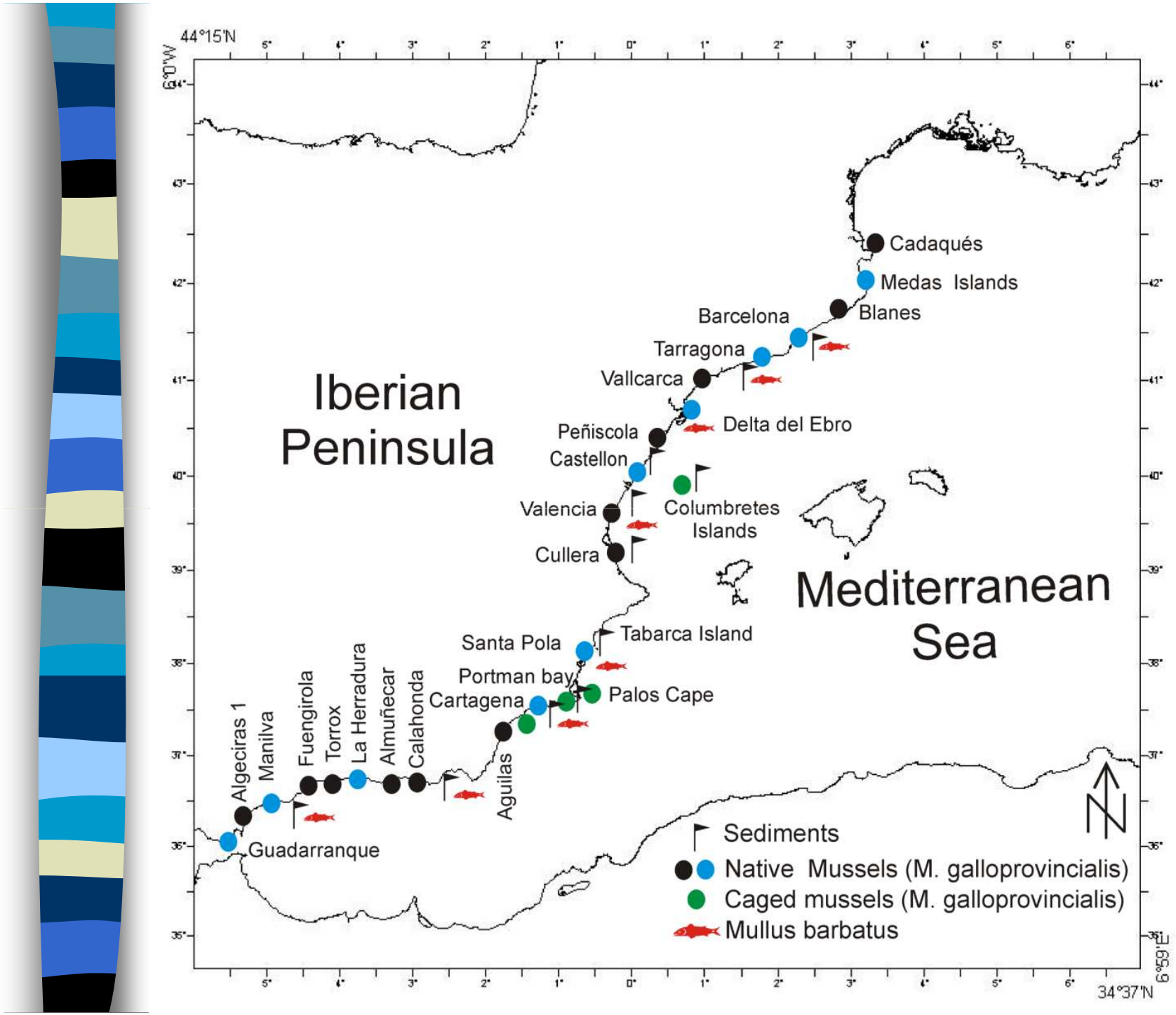
Red mullet

- Genotoxic damages
- EROD
- Micronuclei
- AChE
- Metallothioneins
- ALA-D

Two- tier approach

Sediments

- Embryotoxicity test

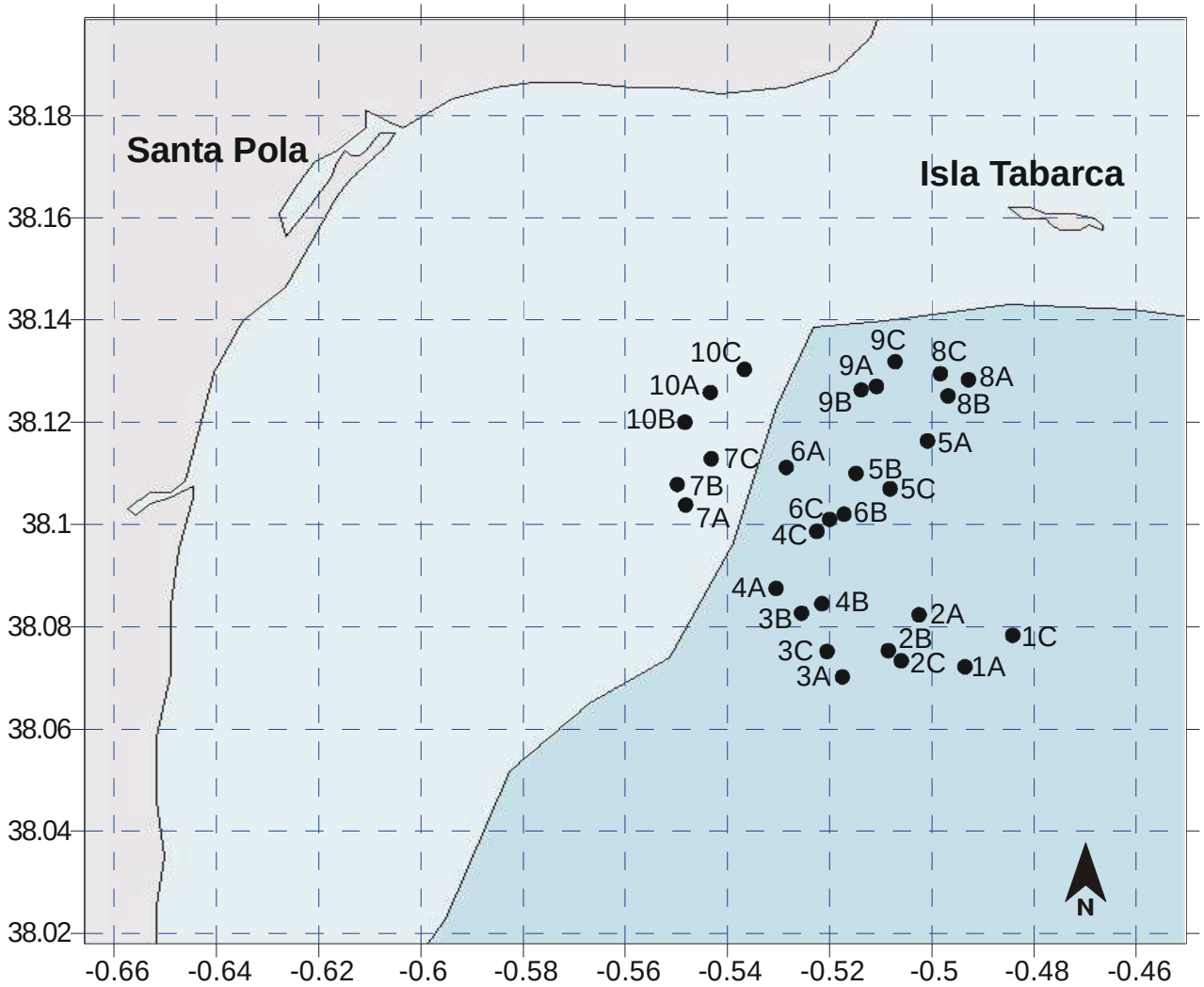

44°15'N
6°0'W
34°37'N
1°55'E
Iberian Peninsula
Mediterranean Sea
Cadaqués
Medas Islands
Blanes
Barcelona
Tarragona
Vallcarca
Delta del Ebro
Peñiscola
Castellon
Columbretes Islands
Valencia
Cullera
Tabarca Island
Santa Pola
Portman bay
Palos Cape
Cartagena
Aguilas
Calahonda
Almuñecar
La Herradura
Torrox
Fuengirola
Manilva
Algeciras 1
Guadarranque
Sediments
Native Mussels (M. galloprovincialis)
Caged mussels (M. galloprovincialis)
Mullus barbatus

BMIS program: Integrated sampling strategy

Sampling sediments: Pilot study 2006-2007-2008

SIZE SAMPLING: 3 samples/nautical mile^2

Analysis of contaminants in <2 mm fraction



Sampling sediments: Pilot study 2006-2007-2008

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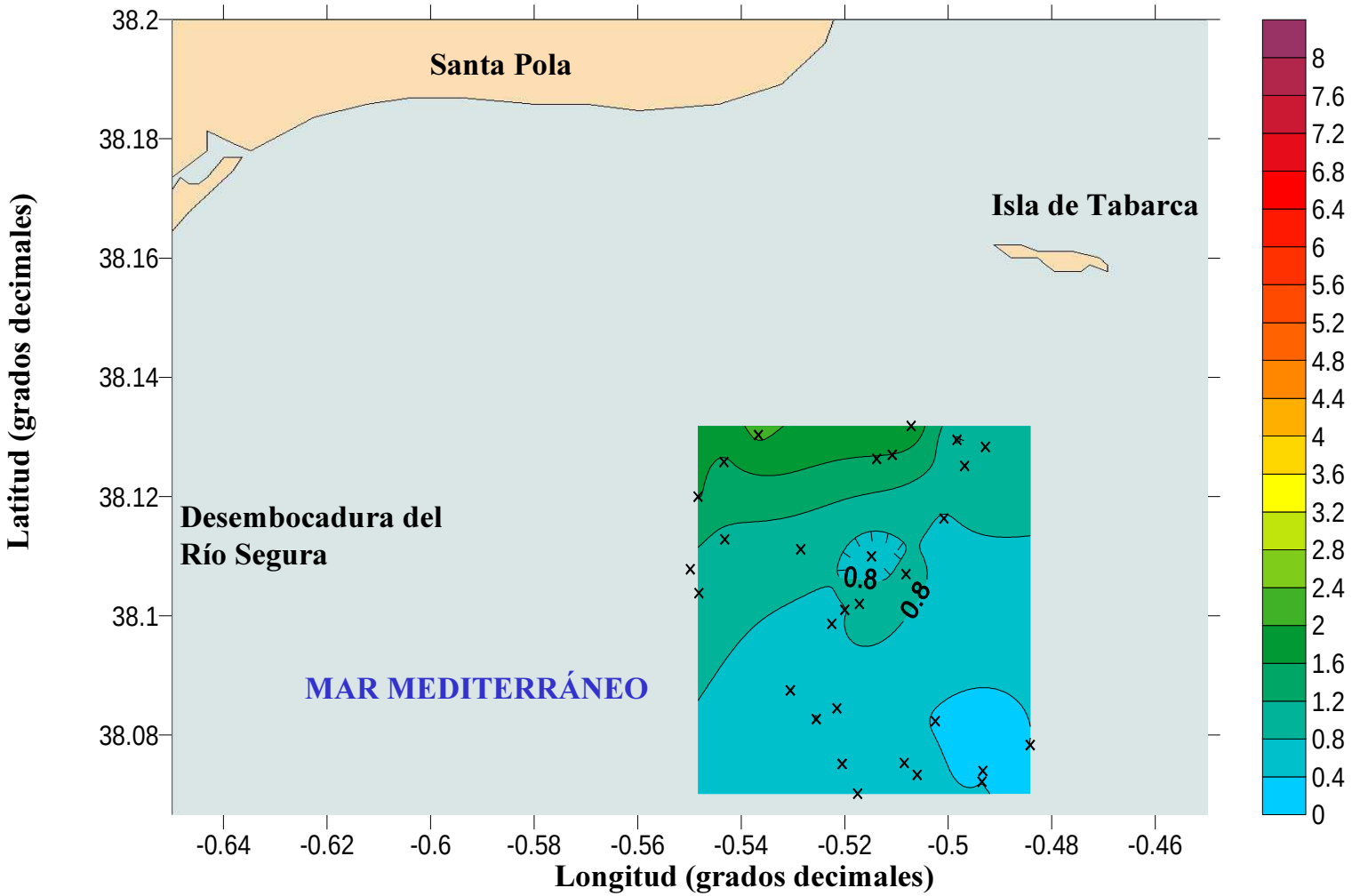
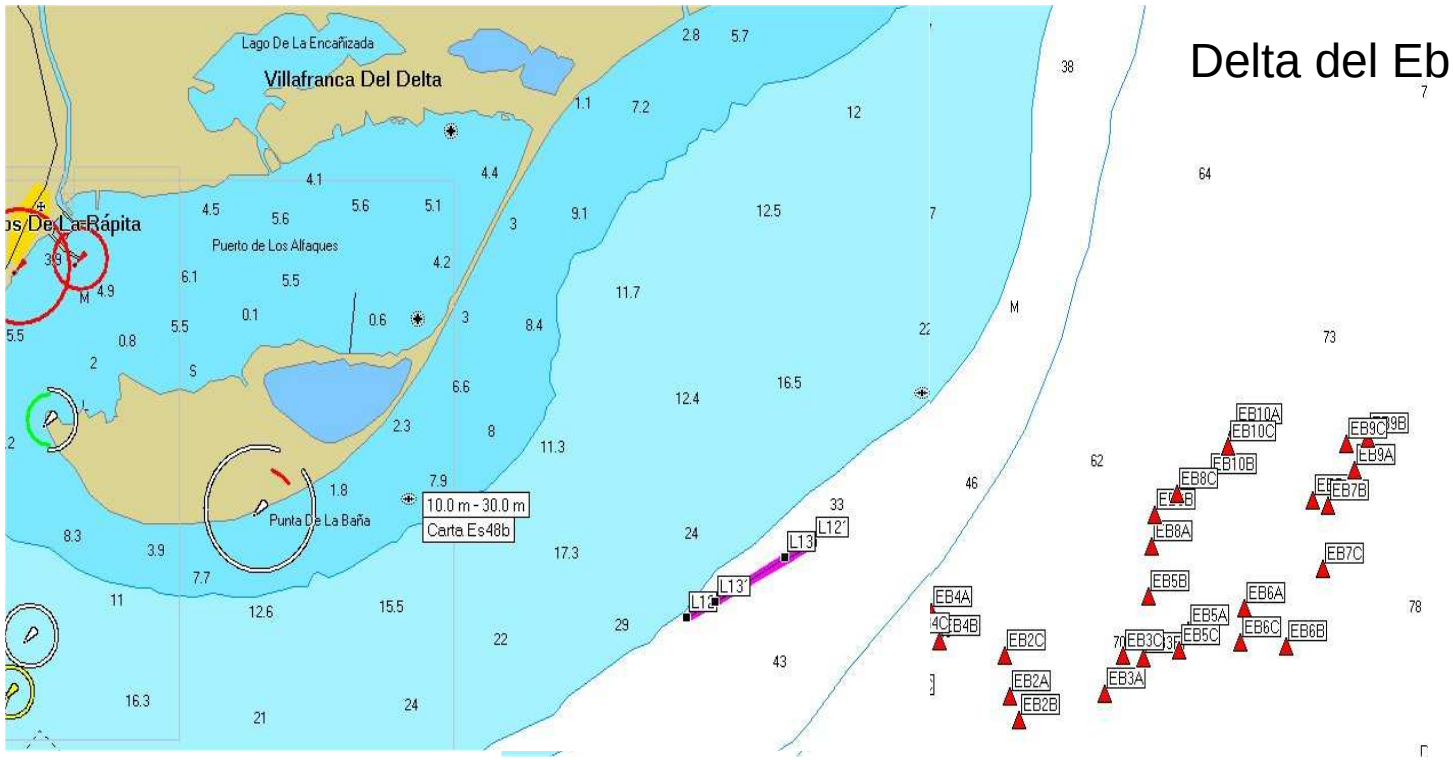


BMIS program: Integrated sampling strategy

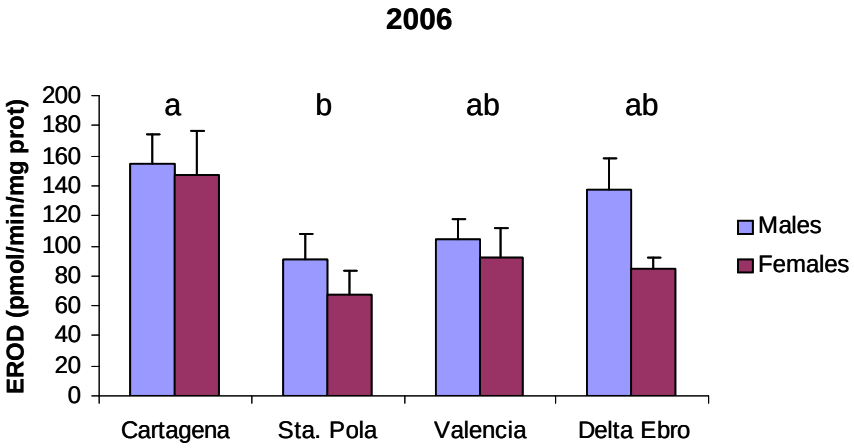
(fish and sediment components)

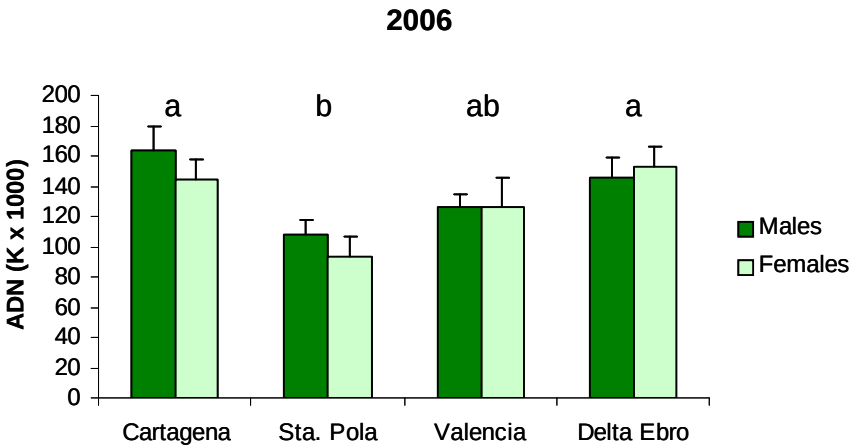


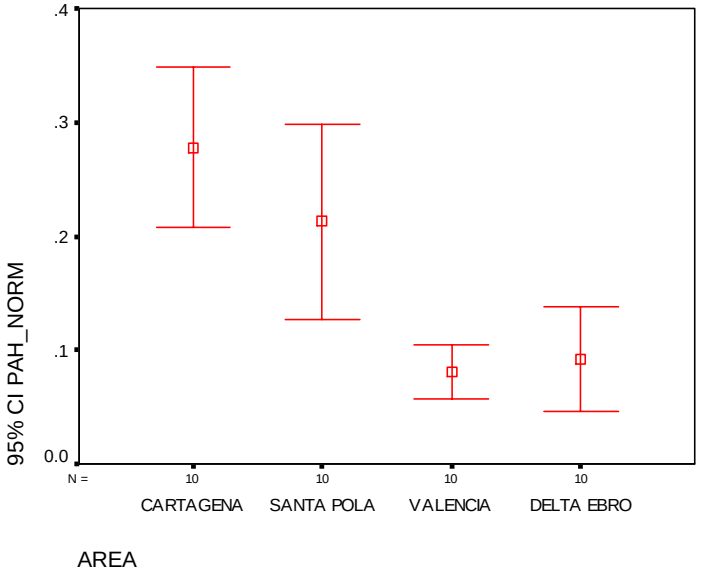
Delta del Ebro

Some Preliminary Results

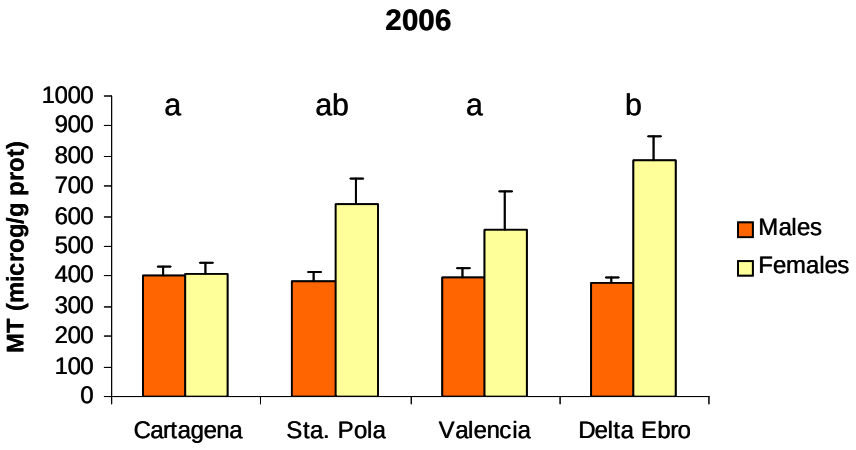
EROD activity , Genotoxic damages and PAH concentration in red mullet, 2006

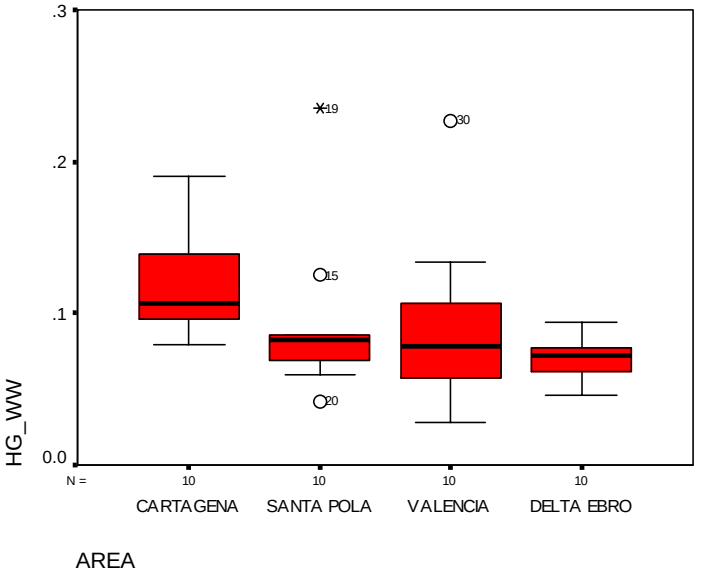


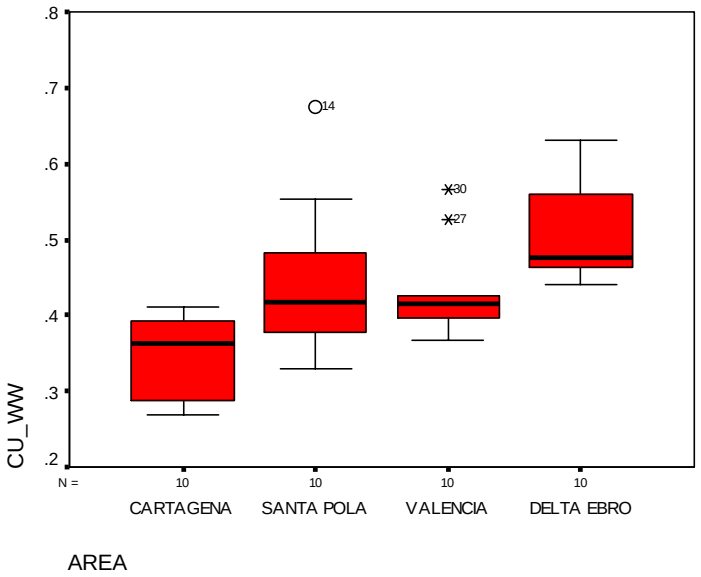


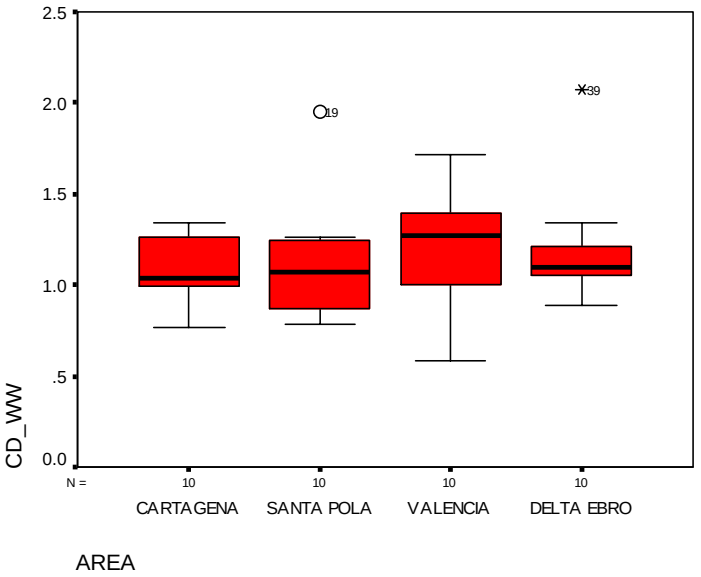


Metallothionein content, Hg, Cu and Cd concentration in red mullet, 2006.

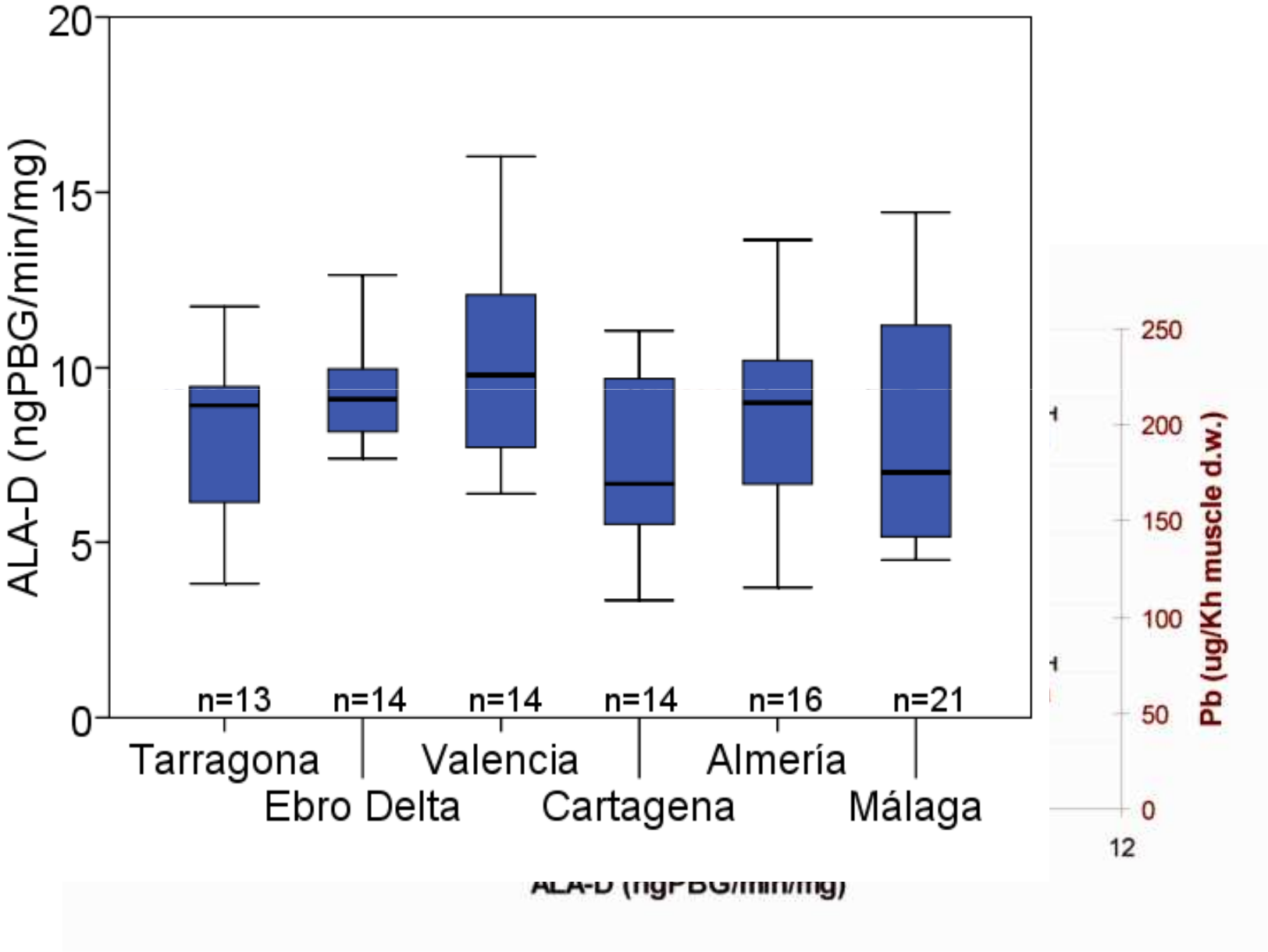




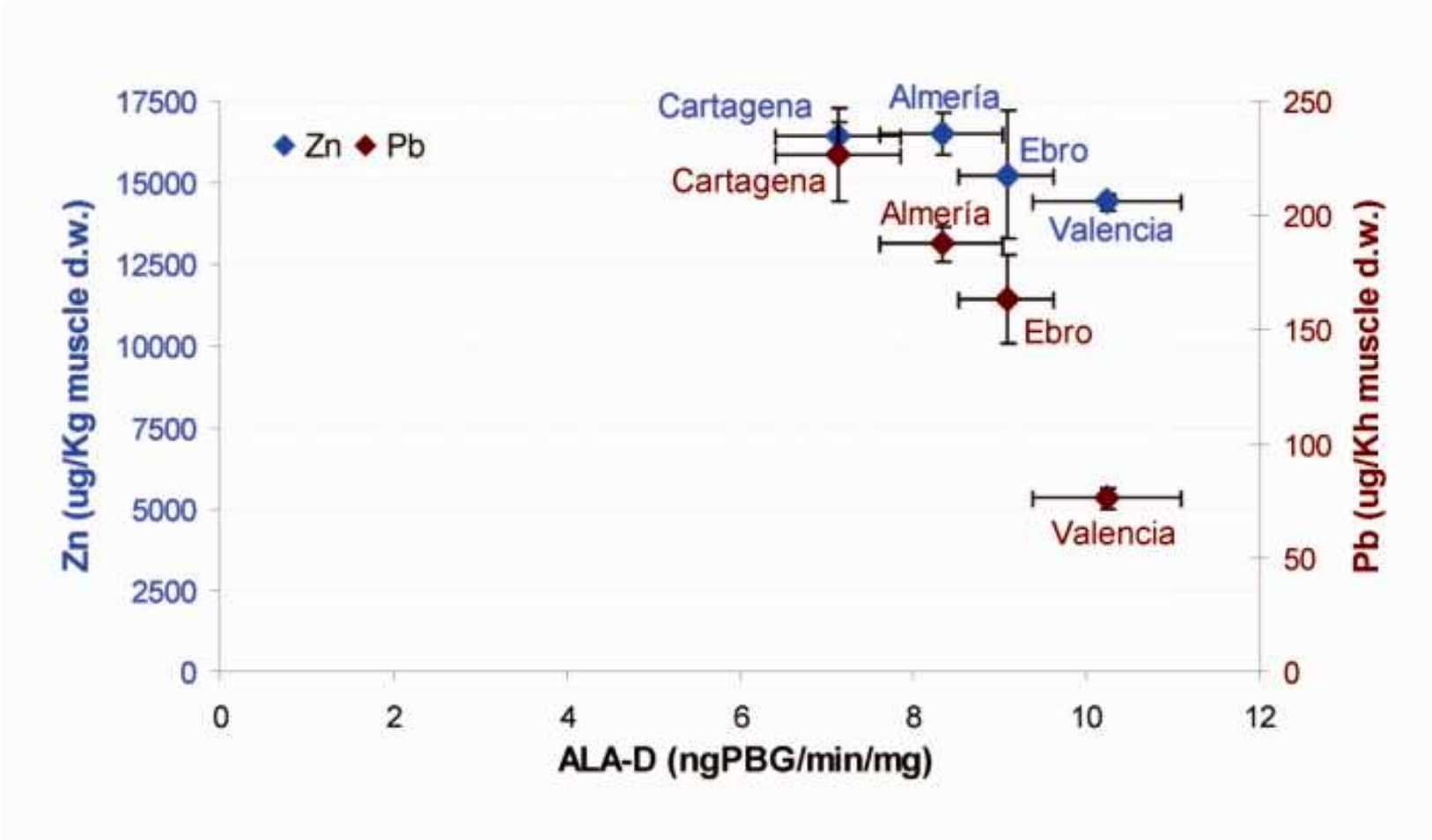




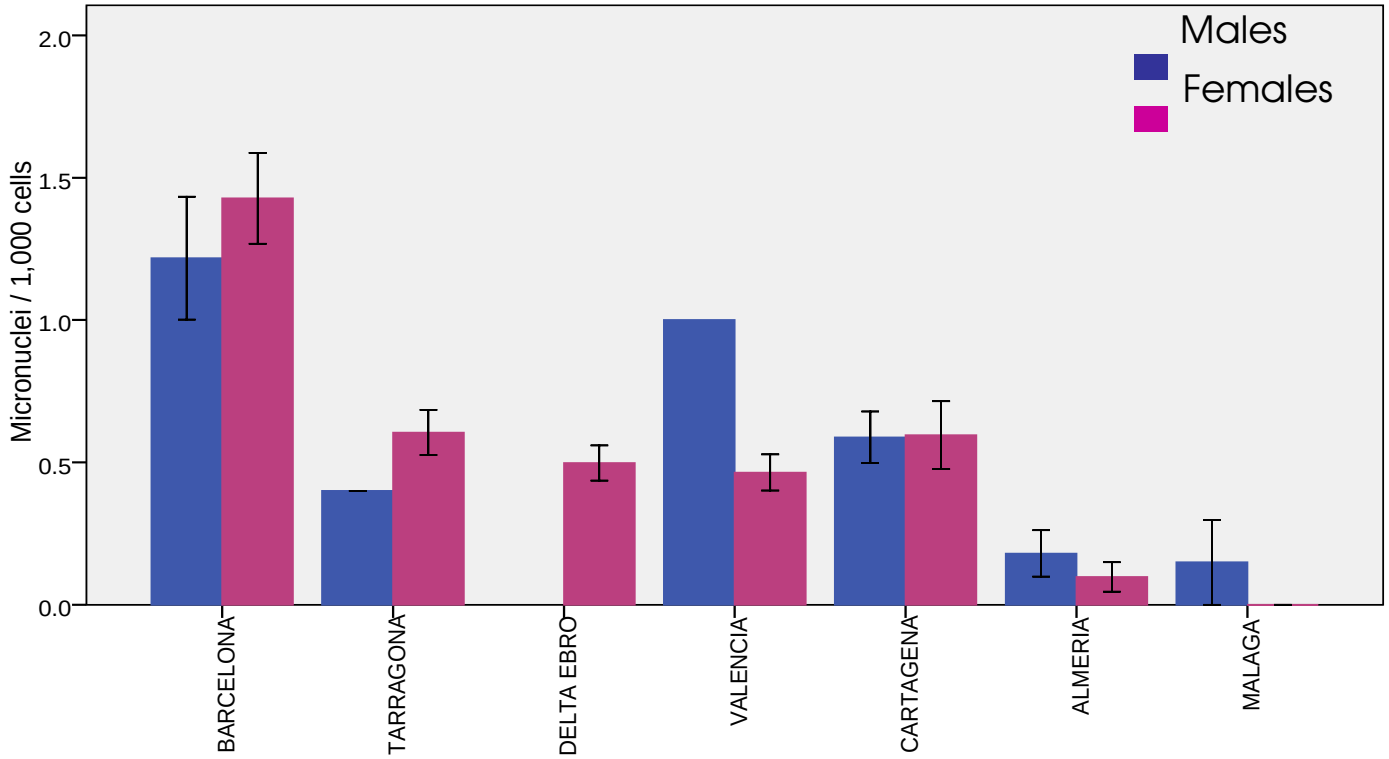
Ala-D activity in red mullet, 2008.

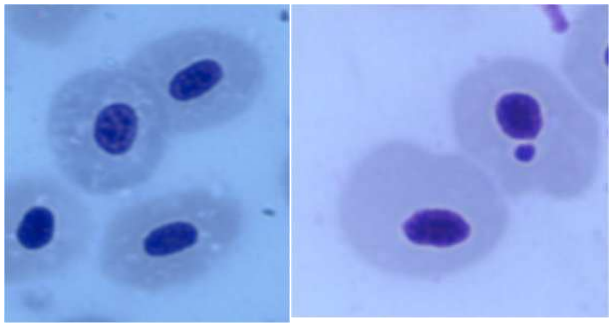


Ala-D activity in red mullet, 2008.



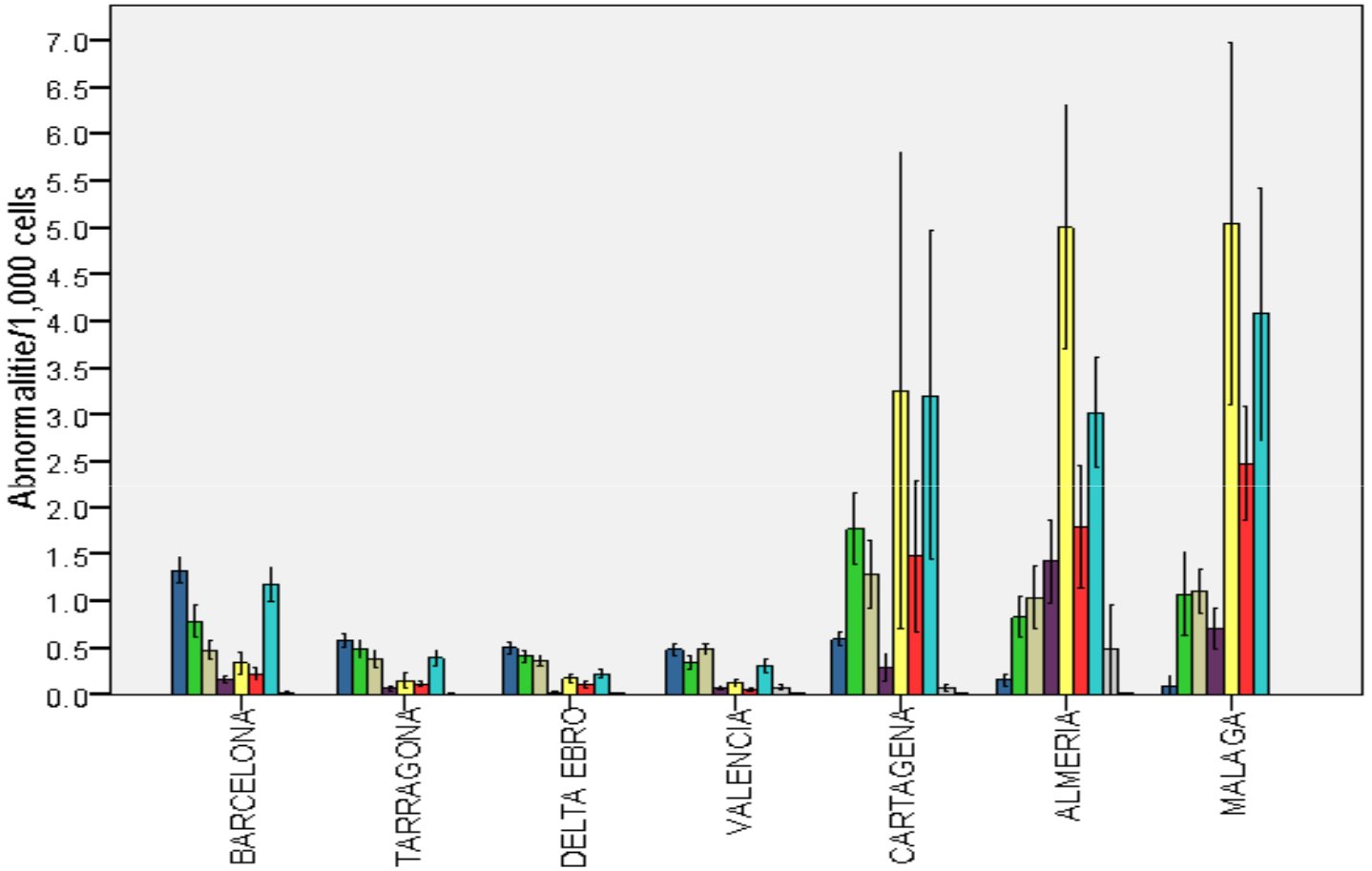
Nuclear abnormalities in red mullet, 2008.

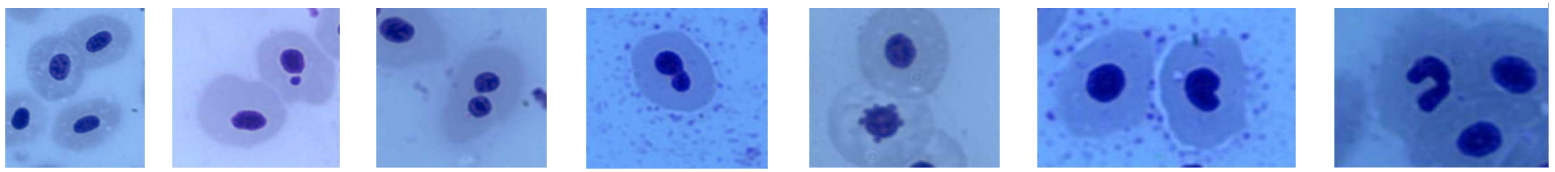




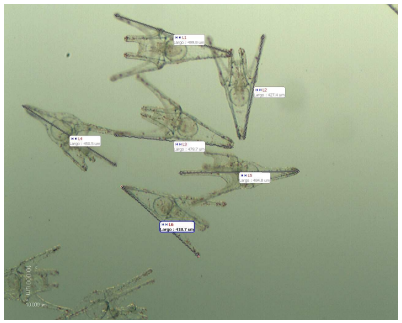
Highest MN frequency in erythrocytes of fish from Barcelona (1.3 ‰)

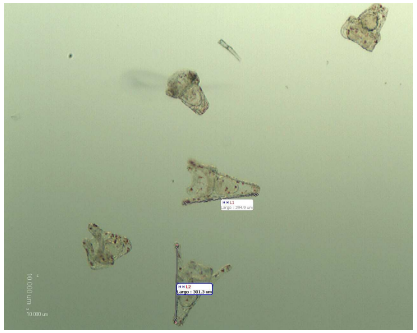
Nuclear abnormalities in red mullet, 2008.





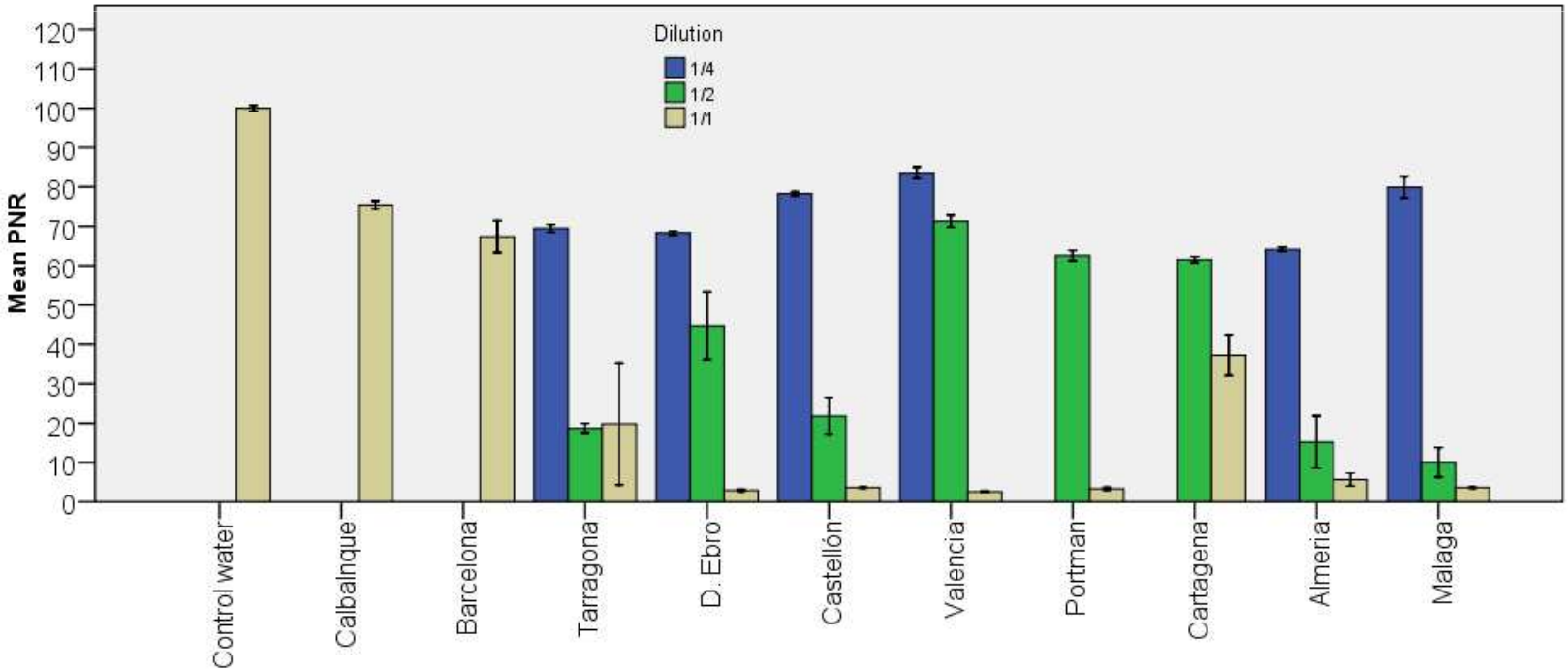
Contaminant in sediments, 2007-2008





PNR (Percentage Net Response)

PNR = (S1-S0) / (SC-SO)



Integrated assessmenent of chemical and biologica effects measurements

- Develop ACs for MPIs
- Assess each of them in synthethic categories

Background response	Elevated background response	High qand cause for concern response

- According their ecological relevance, response of each MPIs will be weighted

Establishment of ACs for Biological responses in BMIS program

Background responses from presumed relatively unpolluted "reference" areas:

Valencia, Santa Pola, Almería and Málga.

EROD in Red Mullet:	≤ 208 pmol/min/mg protein S9 in males 12-18 cm pre-spawning
Metallothionein: pre-	≤ 571 mg/g in males 12-18 cm in males spawning
DNA integrity:	k ≤ 0.172 pooled sex 12-18 cm

Elevated biological response: Above the empirical 90 quantile

Establishment of ACs for Biological responses in BMIS program

Background levels from presumed relatively unpolluted "reference" areas:

Valencia, Santa Pola, Almería and Málga.

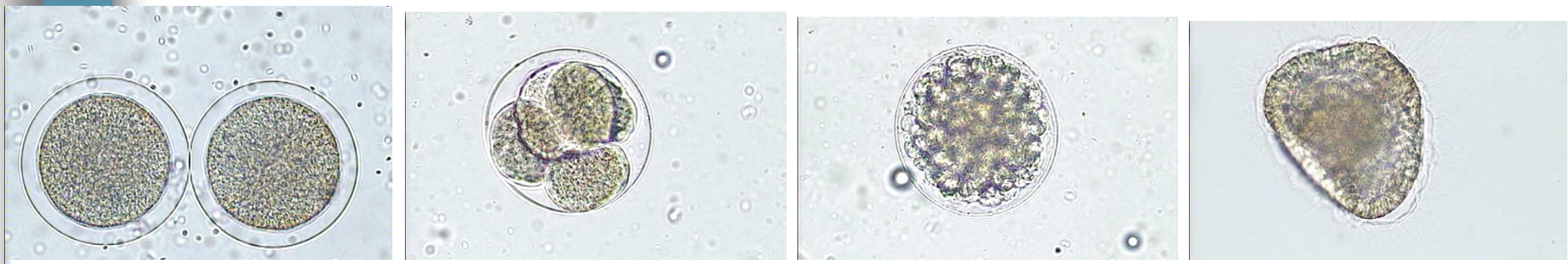
MN frequency: Lowest found in fish from Almería **(0.16 ‰)** and Málaga **(0.10 ‰).**

Bolognesi et al., 20060 = 0.33 ‰ ≤ 0.33 ‰

ALA-D background response (ng PBG min-1 mg-1)

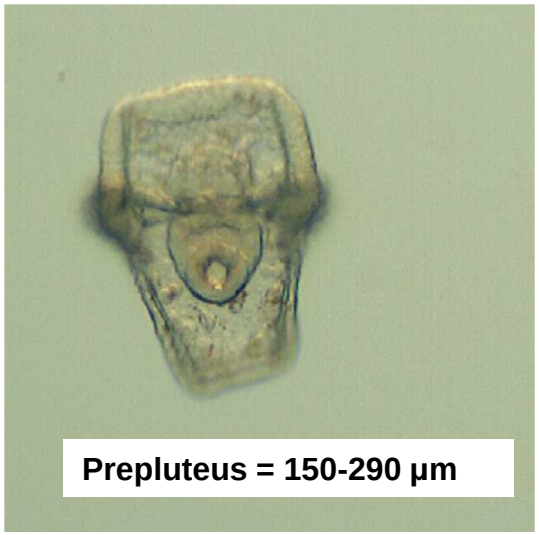
- Red mullet **11-15**
- Flounder and plaice: 13–21
- Atlantic cod 15-21
- dab 10-20

Assessment criteria to classify sampling sites into three different categories of sediment quality status (R. Beiras et al., 2010. ICES TIMES SERIES draft,)

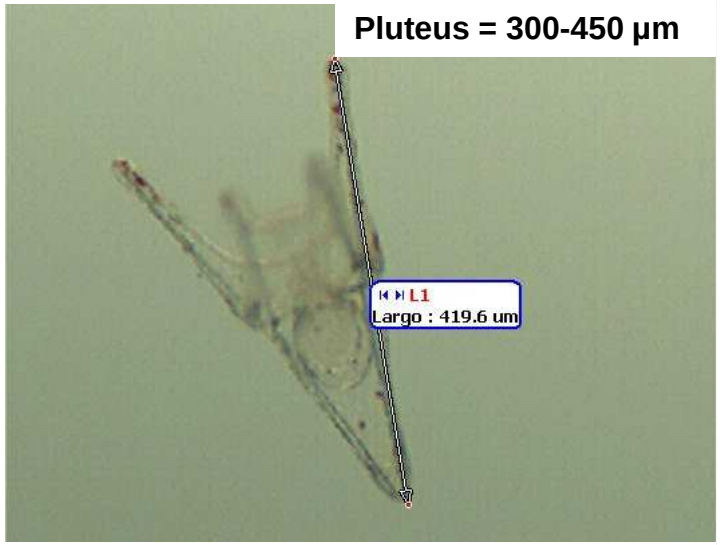


Fertilize eggs = 92 ± 3 µm

Gastrula eggs = 110-130 µm



Prepluteus = 150-290 µm

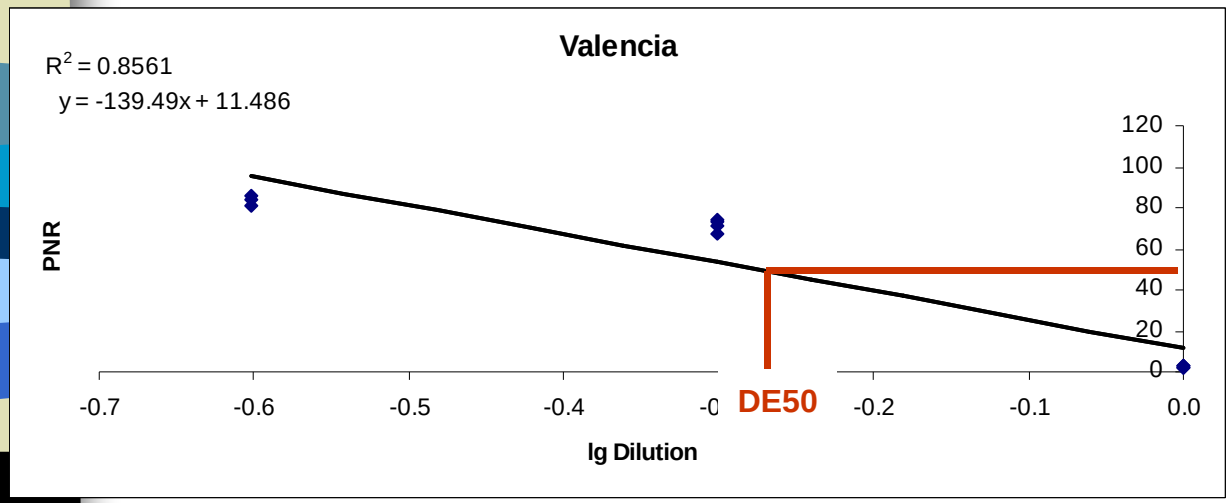


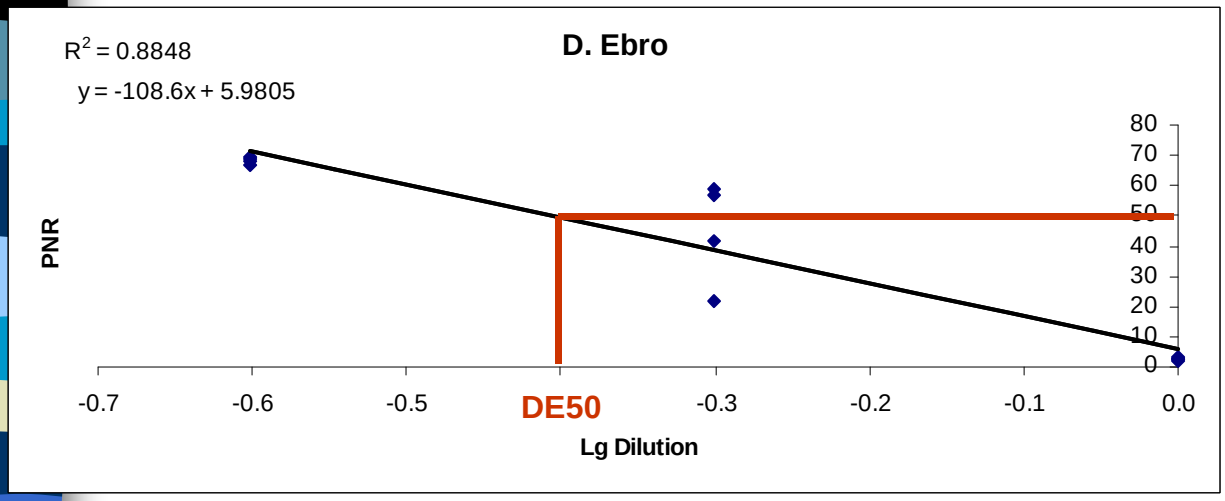
Pluteus = 300-450 µm

Durán and Beiras, 2010. *Environmental Toxicology and Chemistry*, 29(5): 1192:1198

Saco¨´Alvarez et al., 2010. *Ecotoxicology and Environmental Safety*, 73: 491-499

Assessment criteria to classify sampling sites into three different categories of sediment quality status (R. Beiras et al., 2010. ICES TIMES SERIES draft,)



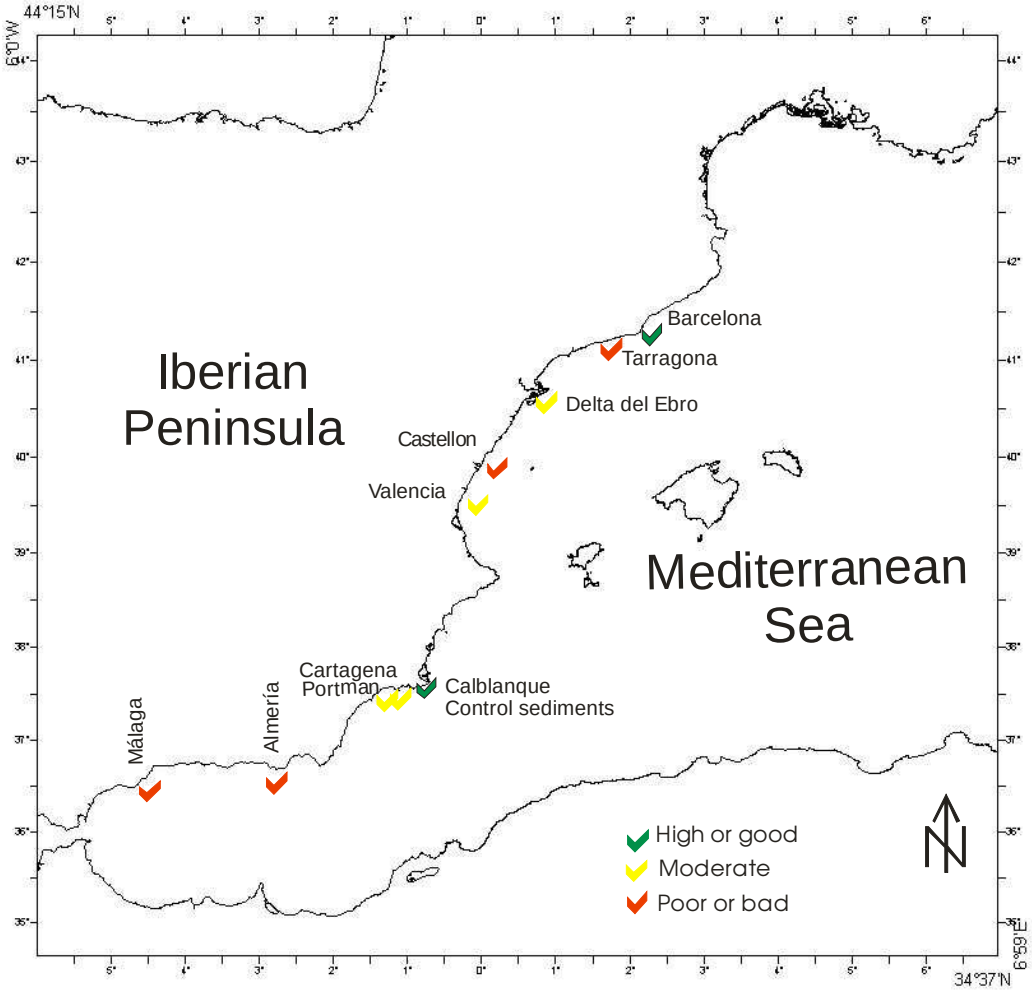


1. Liner regression PNR vs lg Dilution
2. DE50 = dilution causing 50% decrease
3. Obtention TU

TU (Toxic Units)

TU = 100 / DE50

Sediment Quality Status	SET results		
	TU	PNR	"traffic-light" colour code
high or good	<0.27	>0.694	green
moderate	0.27 to 0.86	0.508-0.694	yellow
poor or bad	>0.86	<0.508	red



Preliminary Results of SET test in Biomonitoring program along Iberian inner shelf

Martínez-Gómez et al., 2010. IEO. Centro oceanográfico de Murcia . *Unpublished results. Not to be cited without prior request to the author.*

Establishment of ACs for Biological responses in BMIS program

FUTURE DEVELOPMENT

- To analyse more reccomended MPIs-related in fish from fixed areas: Histochemical techniques and diseases.

FUTURE DEVELOPMENT

- To analyse more reccomended MPIs-related in fish from fixed areas: Histochemical techniques and diseases.

- To review the current MPIS used: MT and DNA integrity.

FUTURE DEVELOPMENT

- To analyse more reccomended MPIs-related in fish from fixed areas: Histochemical techniques and diseases.
- To review the current MPIS used: MT and DNA integrity.
- To Implement more bioassays to be used with sediment samples

FUTURE DEVELOPMENT

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- Different levels of biological organizations: To Integrate BMIS programme with fisheries monitoring surveys….> Crossing data


THANK YOU
MERCIE